Electrical Certification of Wind Turbines on DyNaLab test bench

WIND ASSURING CONFIDENCE THROUGH COMPETENCE

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IQPC
E/E Systems for Wind Turbines

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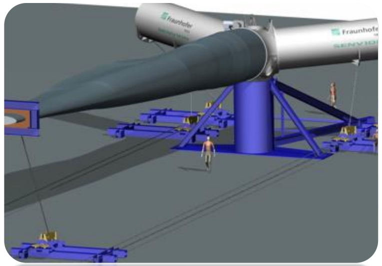
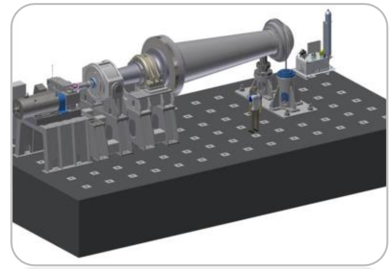
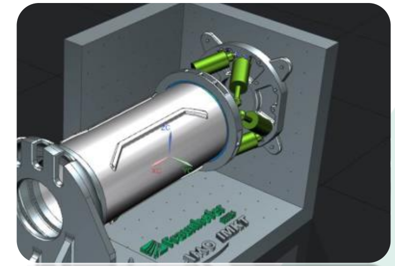
Short profile of Fraunhofer IWES North-West

Managing Director:	Prof. Dr.-Ing. Andreas Reuter
Research spectrum:	Wind energy from material development to grid connection
Operational budget 2014:	around 13,2 million €
Staff:	150 employees
Previous investments in the establishment of the institute:	€ 60 million

Strategic Association with ForWind and the German Aerospace Center (DLR)

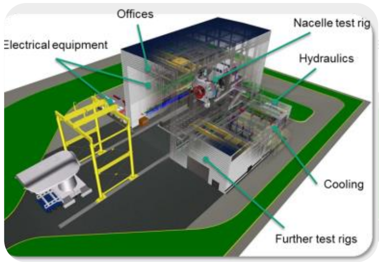






Short profile of Division Wind Turbine and System Technology

Division Manager:	Prof. Dr.-Ing. Jan Wenske
Research spectrum:	Structural durability, mechatronics, power electronics and control in the area of entire wind turbines Large scale test benches for mechanics, electronics and Power mechatronics
Staff:	30 employees
Division locations:	Bremerhaven – Hannover



10MW Full Nacelle Test bench

Design – two ESM on one Shaft - Nominal Power of 10 MW @ 11rpm:

- Civil and building construction 01/14 – 04/15
- Test bench construction 12/14 - 06/15
- Commissioning 05/15 – 09/15
- Transfer of ownership 10/15

Objectives of Multi-Megawatt test benches

JPT Testing:

- Installation of electrical equipment 07/15
- Installation of DUT 08/15

Opening ceremony 10/15

Invest:

- 32 mio €

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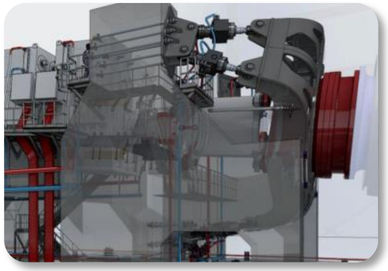
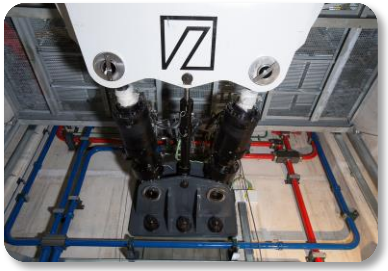
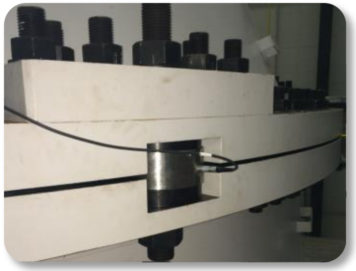






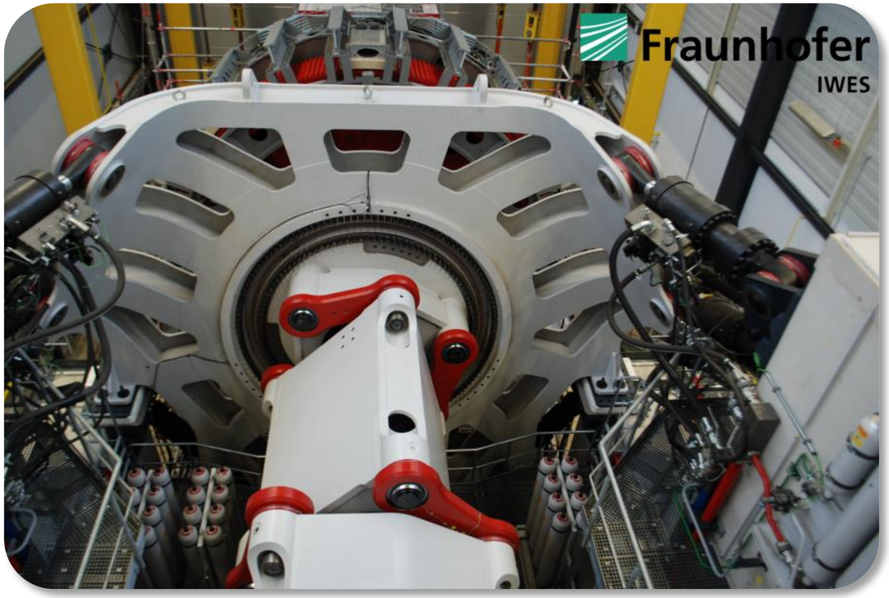
Load Application System

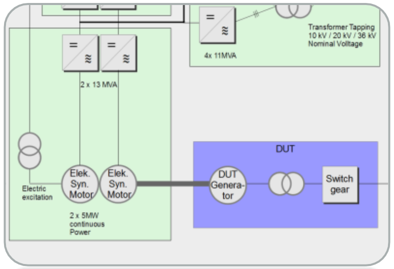
Design – three nominal voltage level

- 5 DOF
- Bending moments up to 20MNm
- Dynamic 0-2 Hz
- 0-G Kit + Blocking cylinders
- 1.2 MW Hydraulic power
- Applying realistic load of recorded time series
- ± 100mm movement of Hexapod

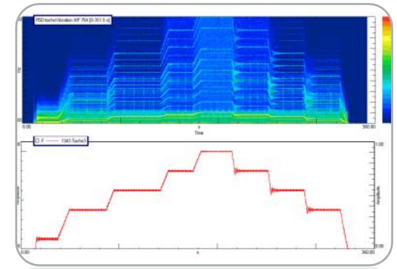
Commissioning:

- Running in position and force Mode
- Running against blocking cylinders
- Calibration of Load application unit by using load cells





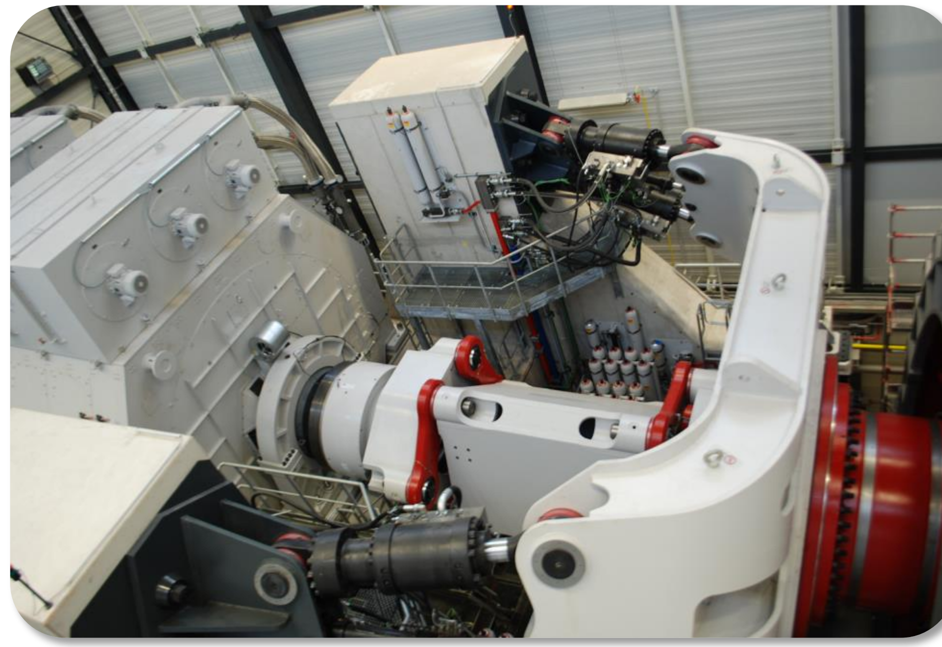




Drivetrain

Design – two ESM on one Shaft - Nominal Power of 10 MW @ 11rpm

- Torque: S1 8600 kNm – S6 13000 kNm
- Motor speed: ± 25 rpm
- Inverters: 2 x 13 MVA
- Stiff drivetrain design



Commissioning:

- Back-to-Back test at nominal design loads
- Heating test
- Dynamic behavior

Auxiliaries:

- Real-time control Interface
- Adjustable safety clutch

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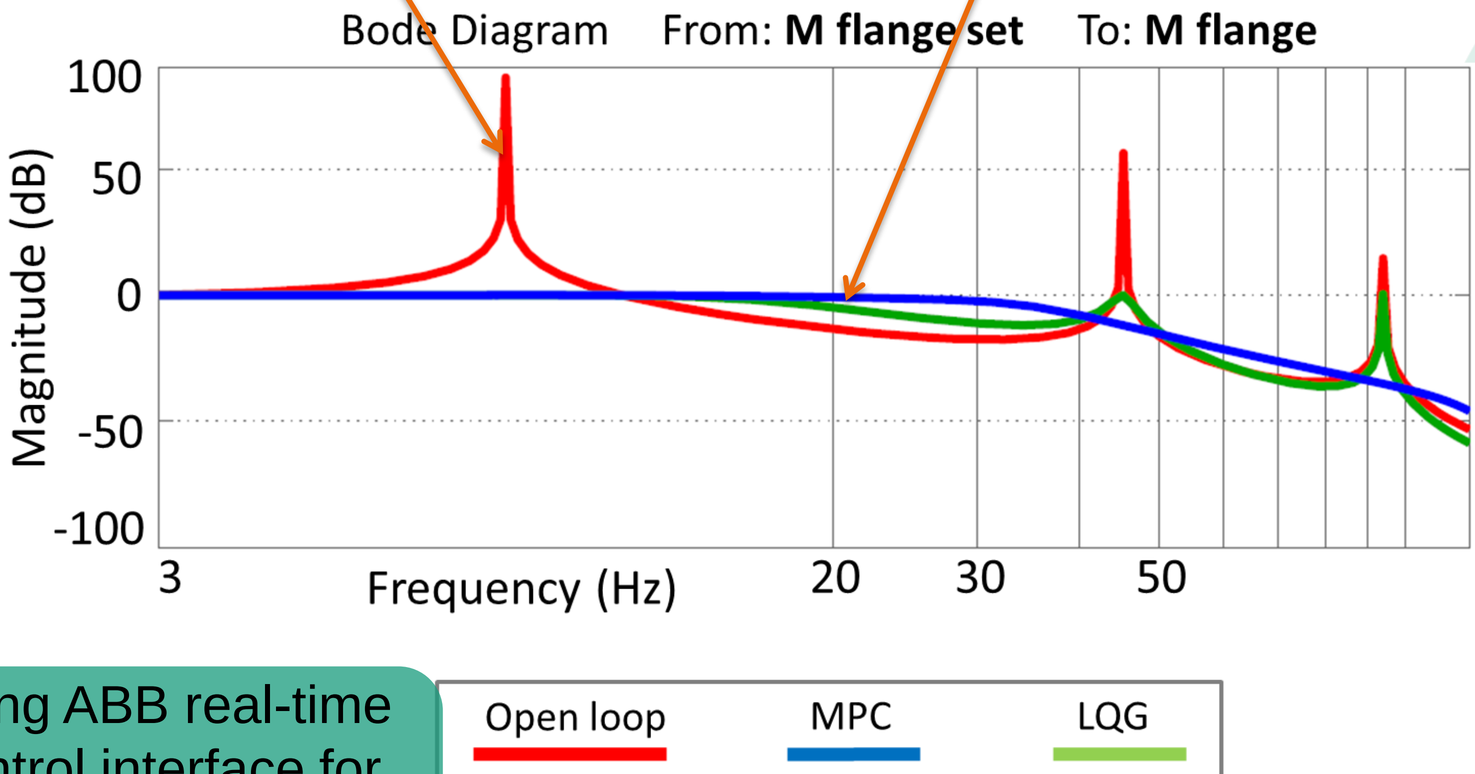
Active damping of DyNaLab drivetrain

1st Eigen frequency of undamped system

Additional energy for active control



Using ABB real-time control interface for advanced control algorithm

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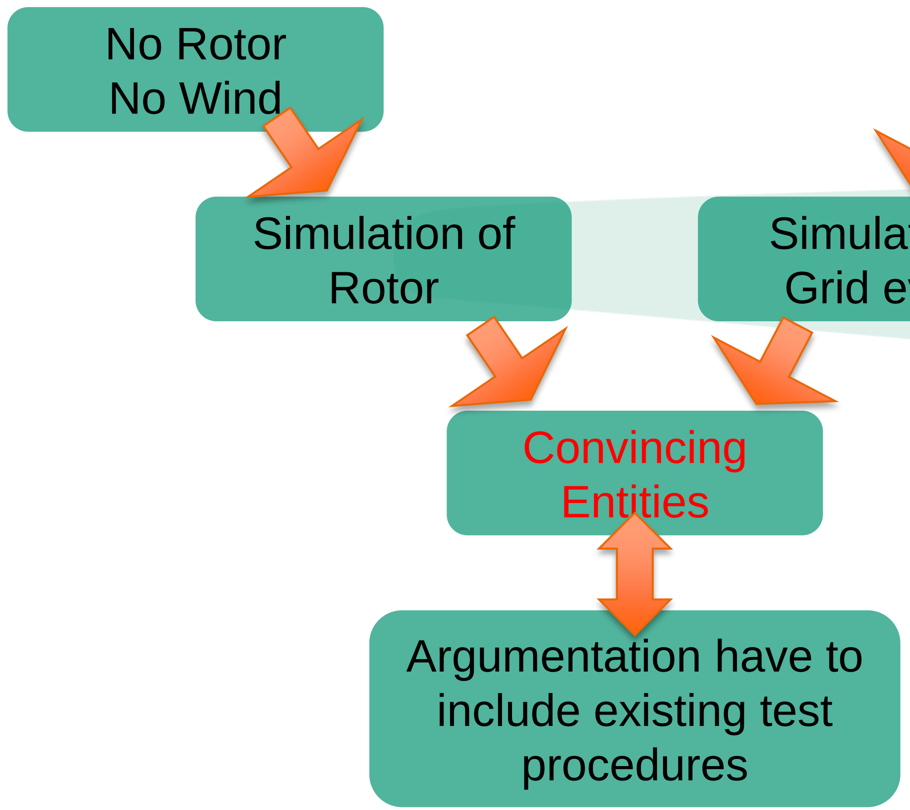
Electrical Certification of WECs on test benches – Acceptance?

- How to introduce a new technology?
- What is different at test bench certification?



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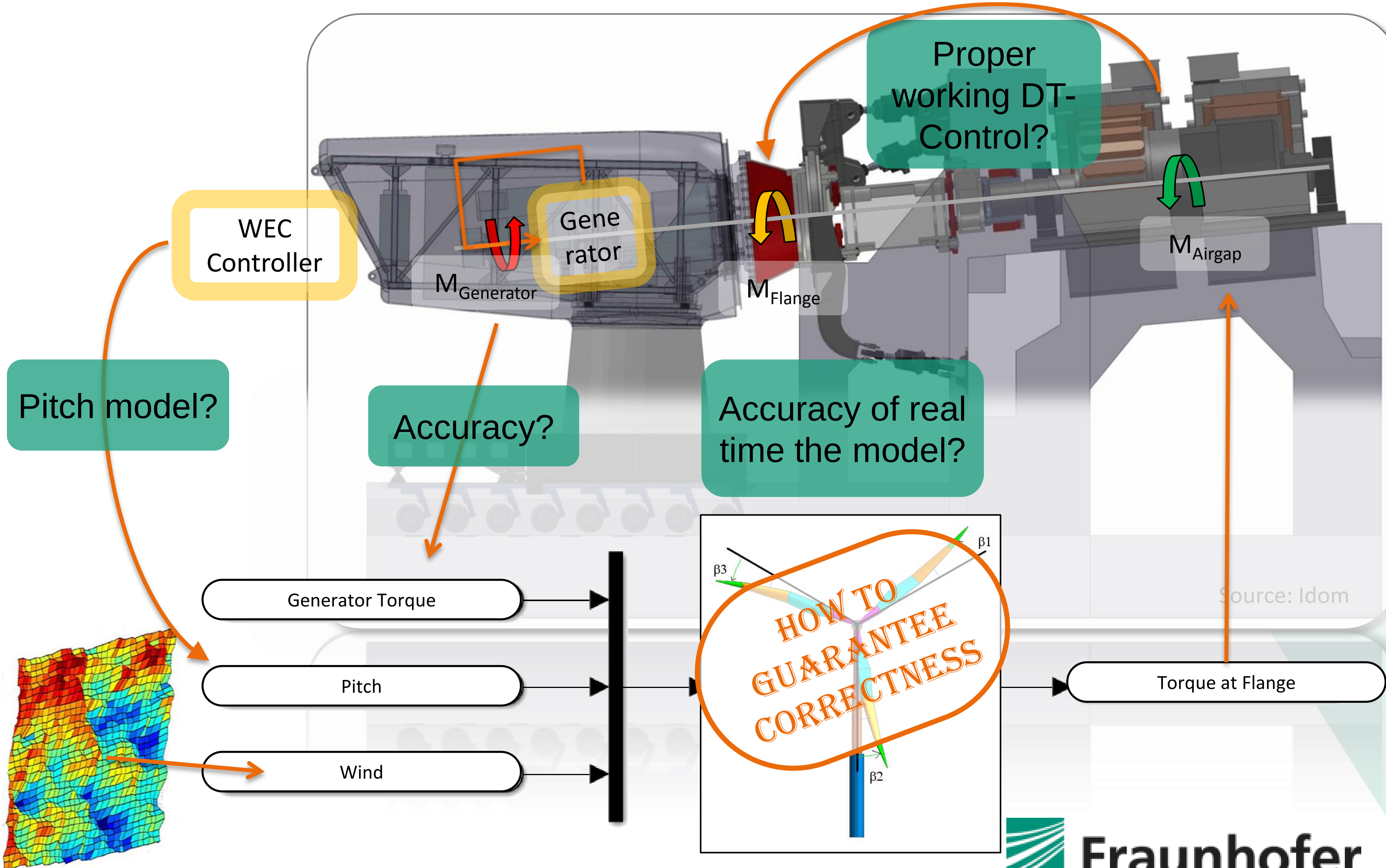
Simulation of realistic rotor behavior at DyNaLab



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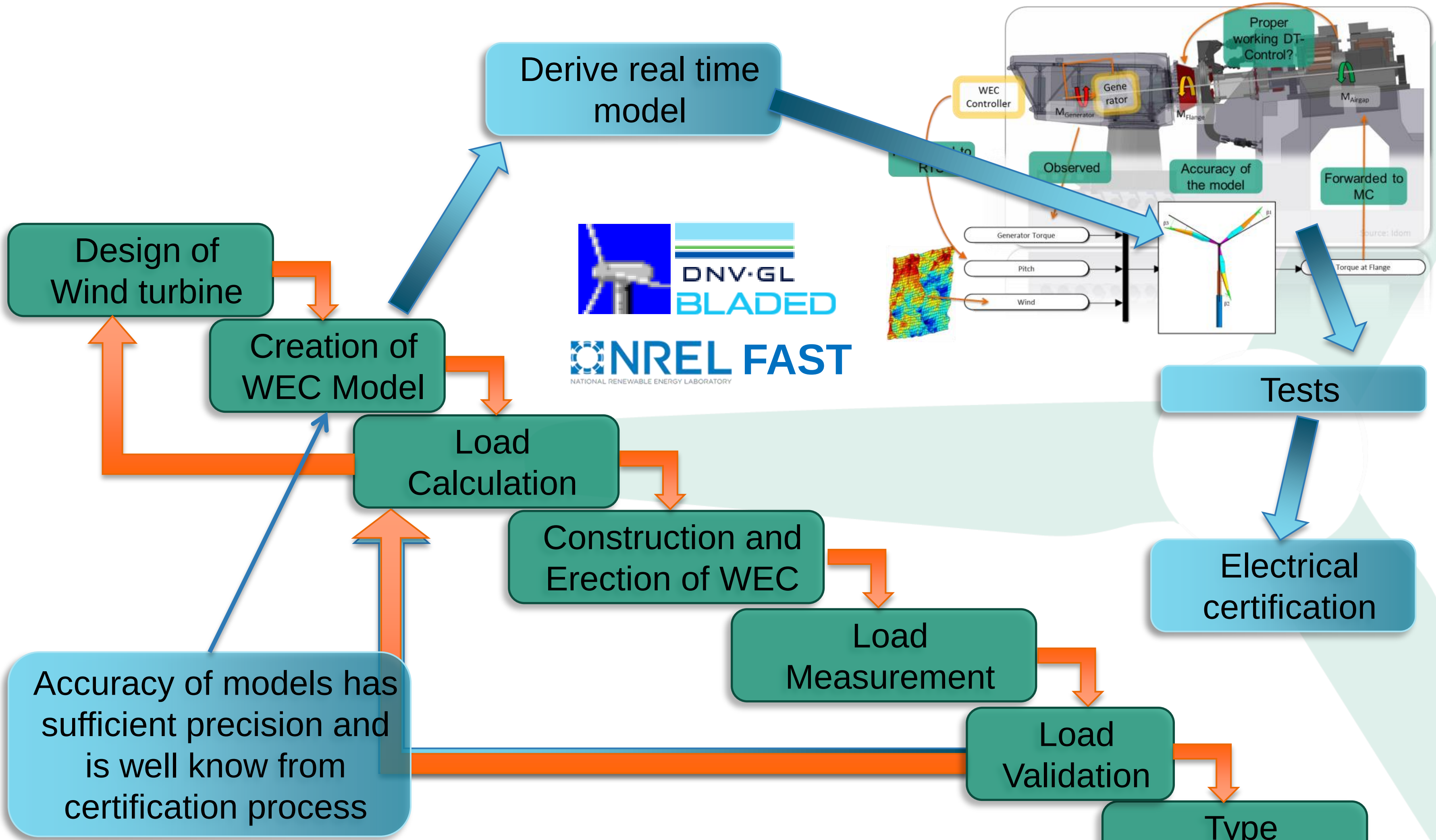
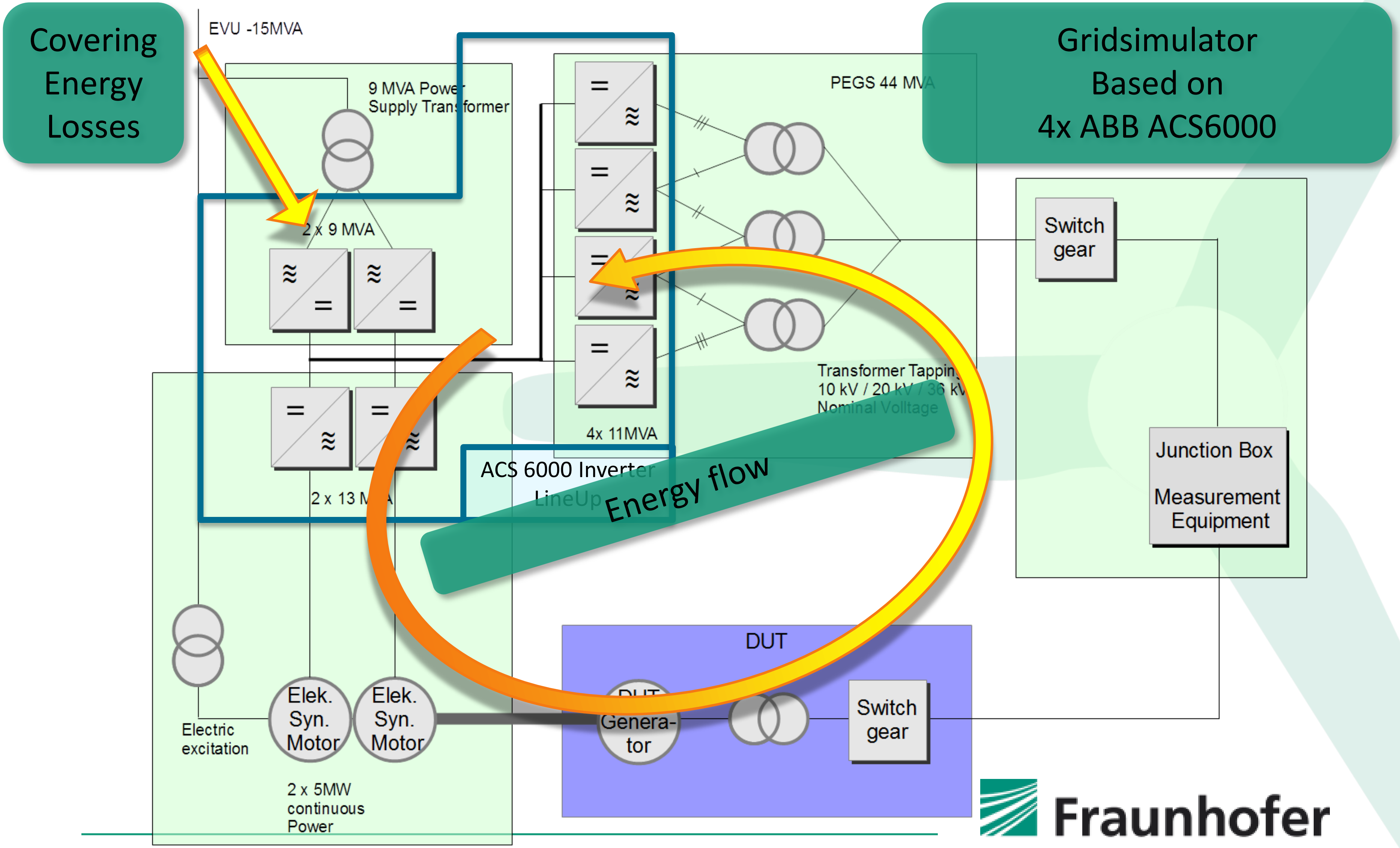
Electrical certification processes – real time model



Overview – Inverters and MV-System



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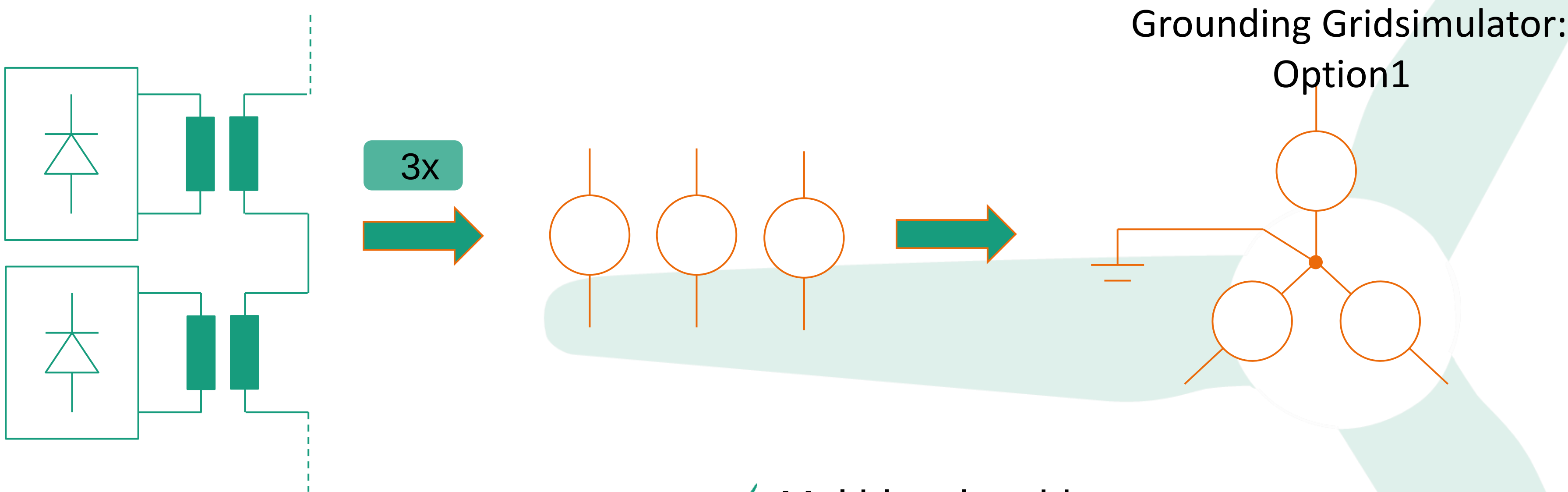
Design of the Gridsimulator

Requirements: Dynamic voltage change, 0V during UVRT, controllable phase, low THD

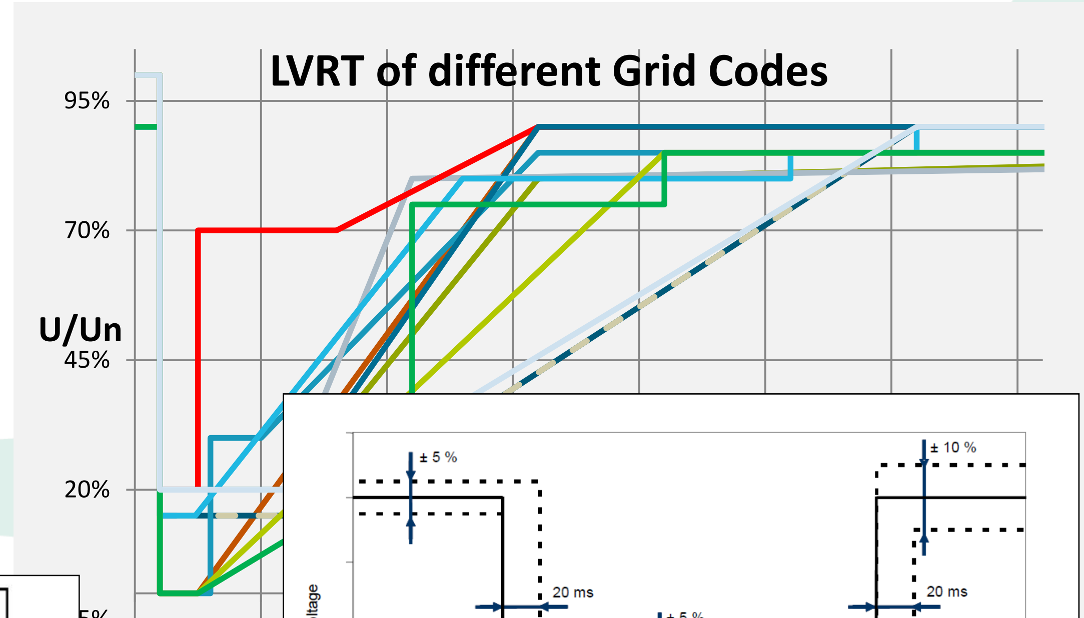


- 3 separate transformer with H-Bridge on lower MV site
- Windings connected in series

- Multi-level architecture
- Elimination of harmonics
- Separate control of each phase
- Several grounding concepts and protection concepts of the grid

LVRT-Container Testing

- Grid Codes: Triangle voltage sags
- Typical LVRT-Container can only provide rectangular voltage sags
- Also shown in IEC 61400-21 (unprecise sketch)



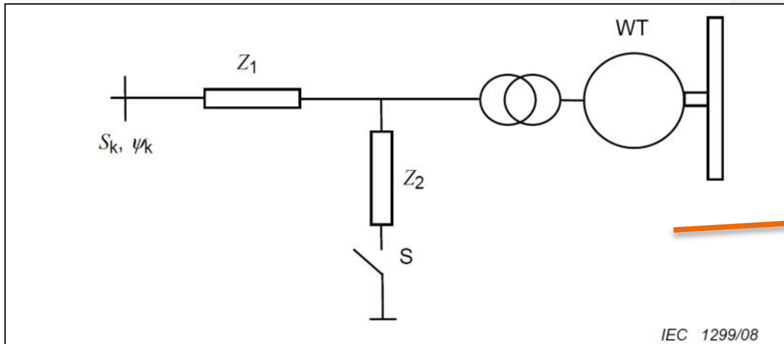


Figure 5 – System with short circuit emulator for testing wind turbine response to temporary voltage drop

Source: IEC 61400-21

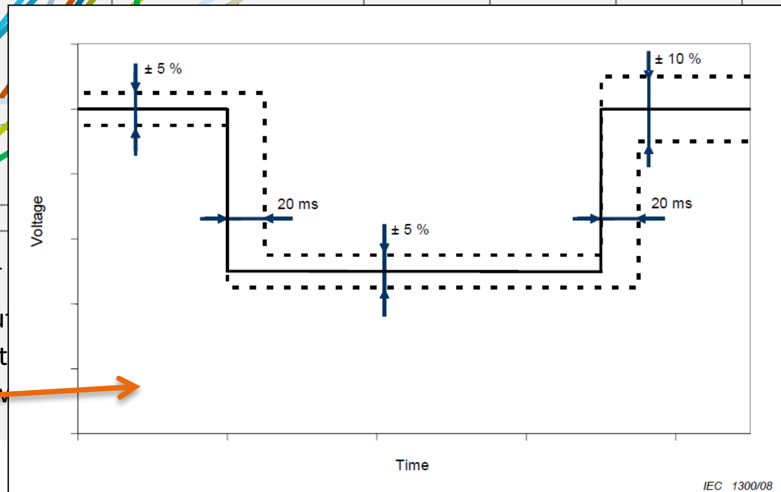


Figure 6 – Tolerance of voltage drop

Source: IEC 61400-21

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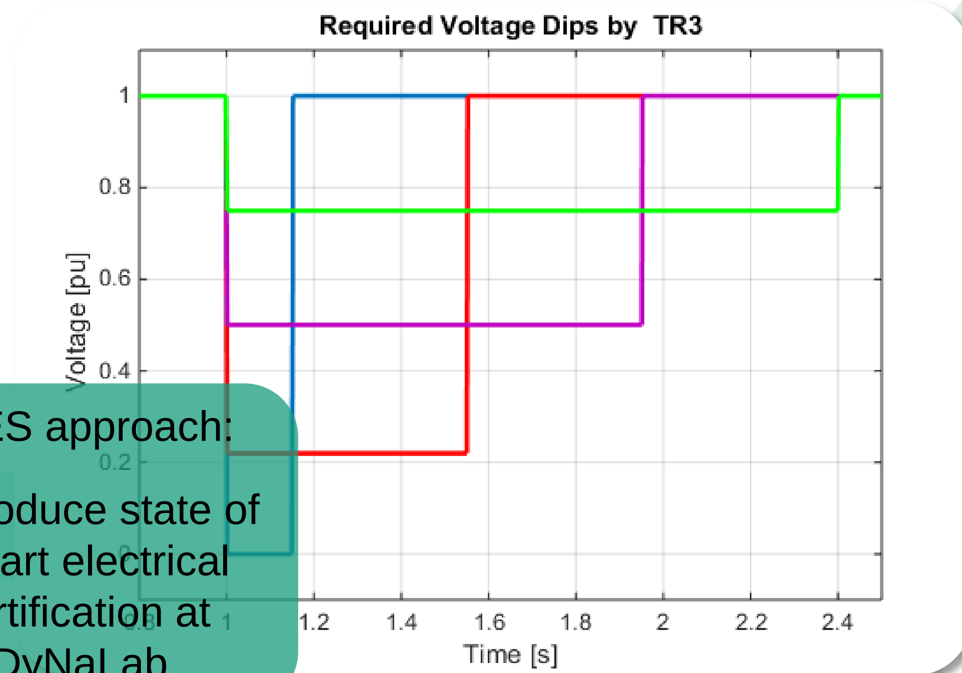
Emulation of LVRT - Dynamic slope of voltages

- Reproducing voltage sag triangle within several tests
- High dynamic voltage slope to receive rectangular voltage curves



DNV-GL TN 066
Required slope of
1 ms

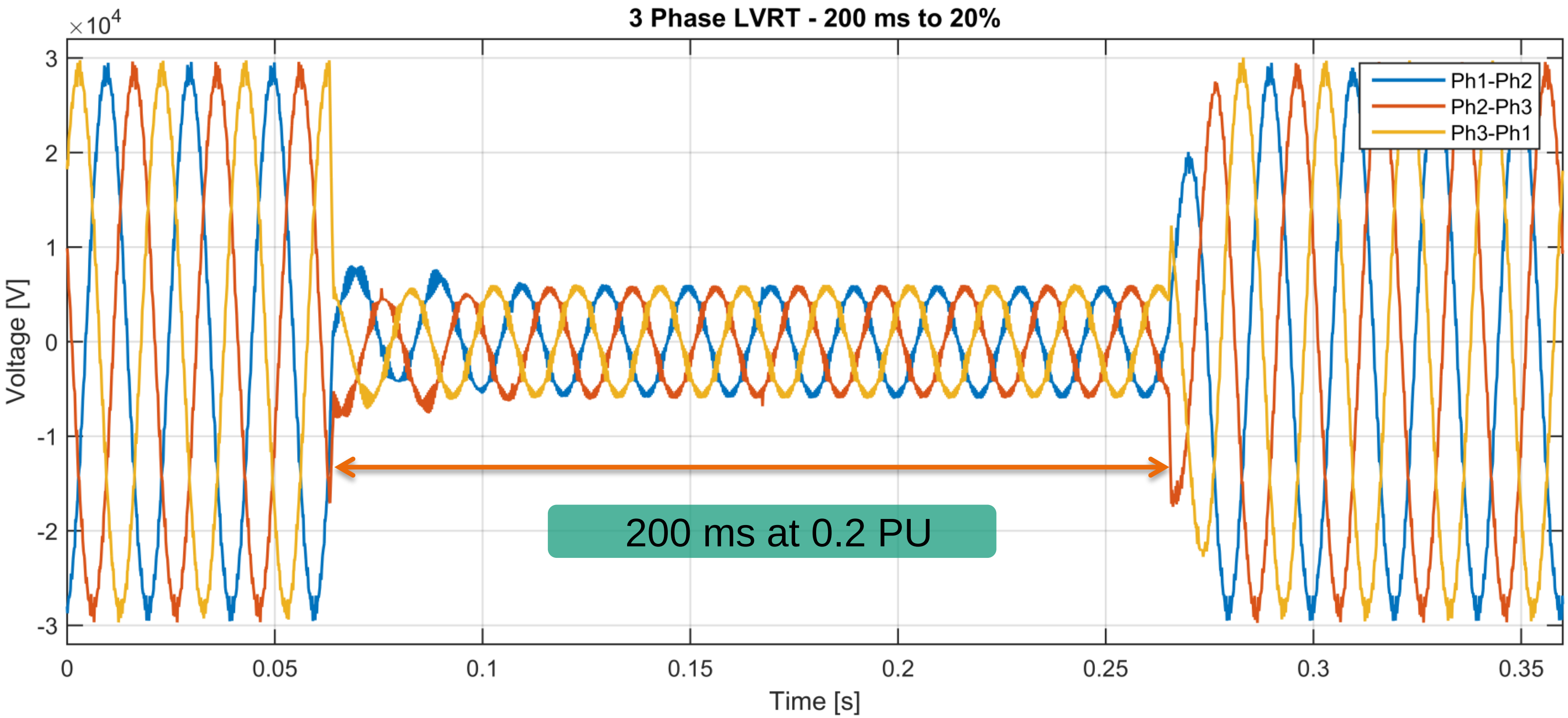
IWES approach:

Reproduce state of the art electrical certification at DyNaLab

The voltage drop can be achieved with a reactor by short-circuiting of two and three phases at the turbine side of the impedance. The test set up according to IEC 61400-21 /4/, section 7.5 can be used (two reactors Z1 and Z2 as a voltage divider). The voltage drop should be accomplished in 1 ms fall time of the signal from U_n down to User at the beginning of the drop – otherwise as fast as possible – so that a short circuit in the grid is reproduced close to reality.

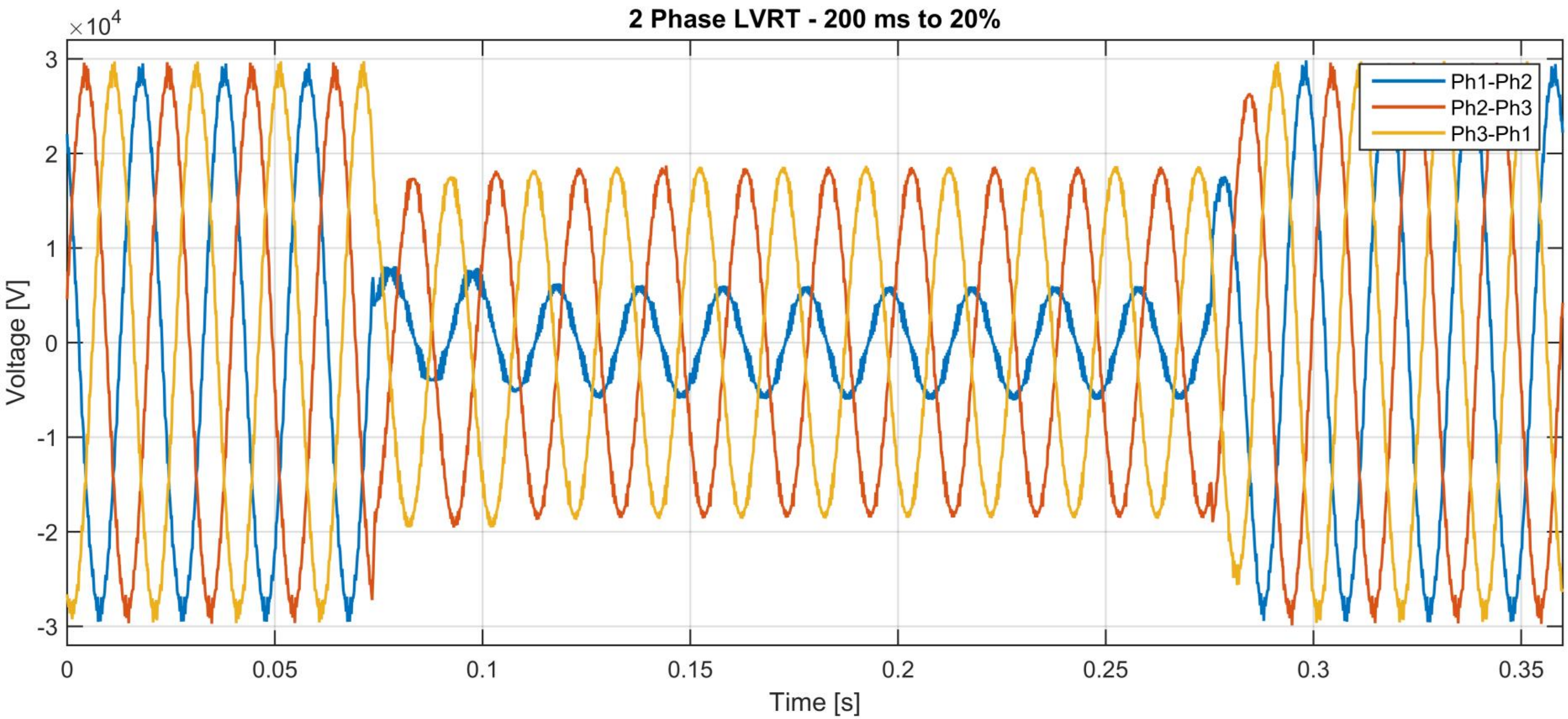
Source: TN066, DNV-GL

Reproducing Voltage Sag of LVRT-Container



Reproducing of 2 Phase Voltage Sag

Indenpent control of each phase



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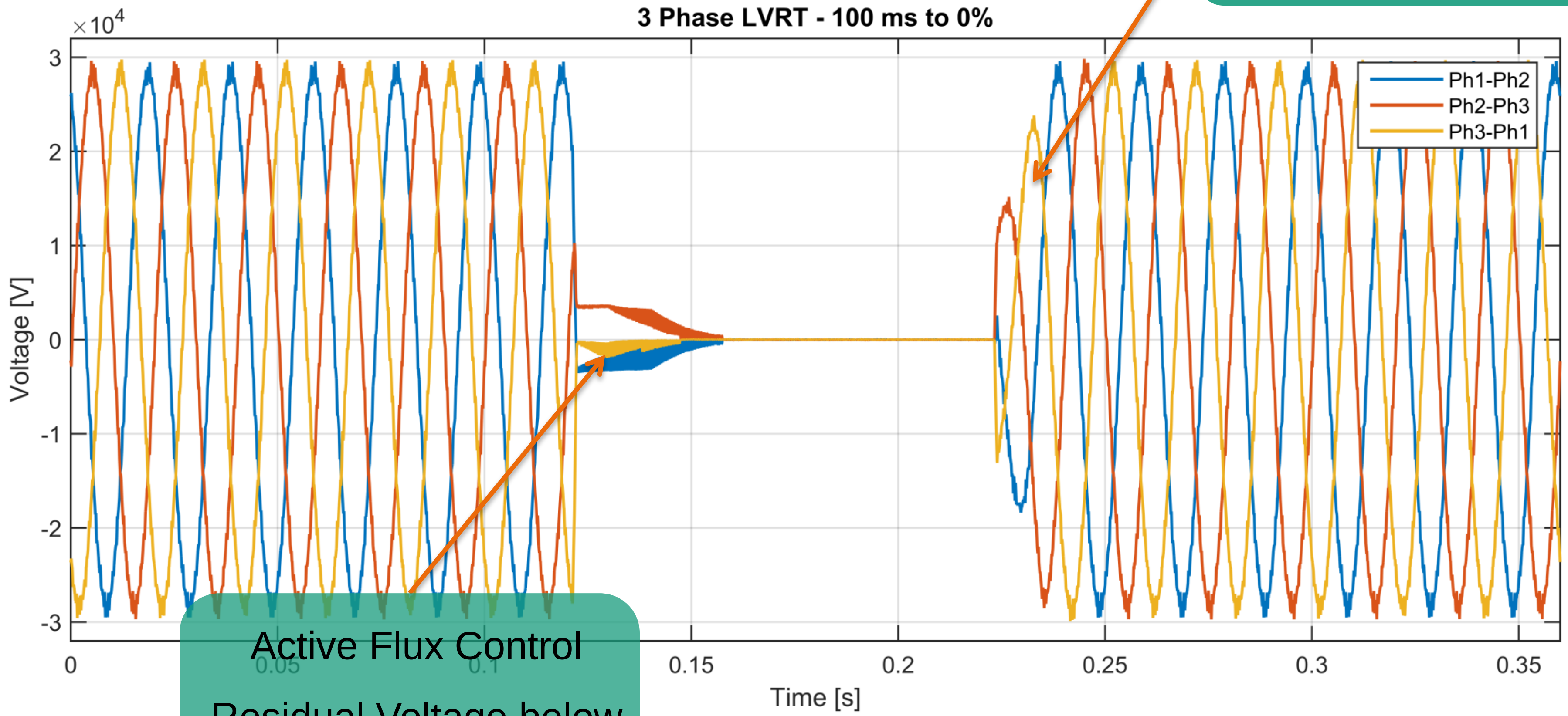
Voltage Sag to 0V

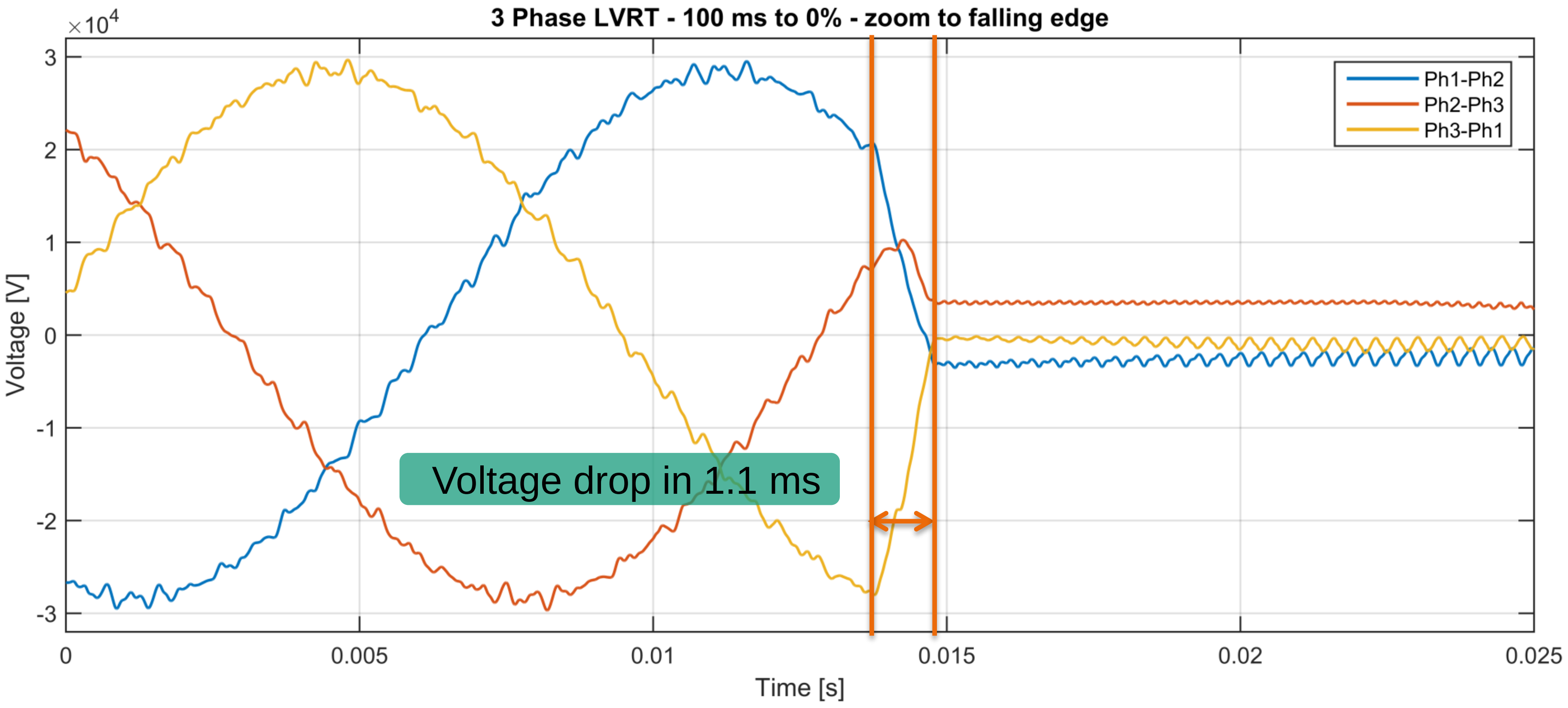
Ramp up
0% - 50% in 1ms
50% -100% in 10ms



Active Flux Control

Residual Voltage below 5%

Detailed view on voltage drop



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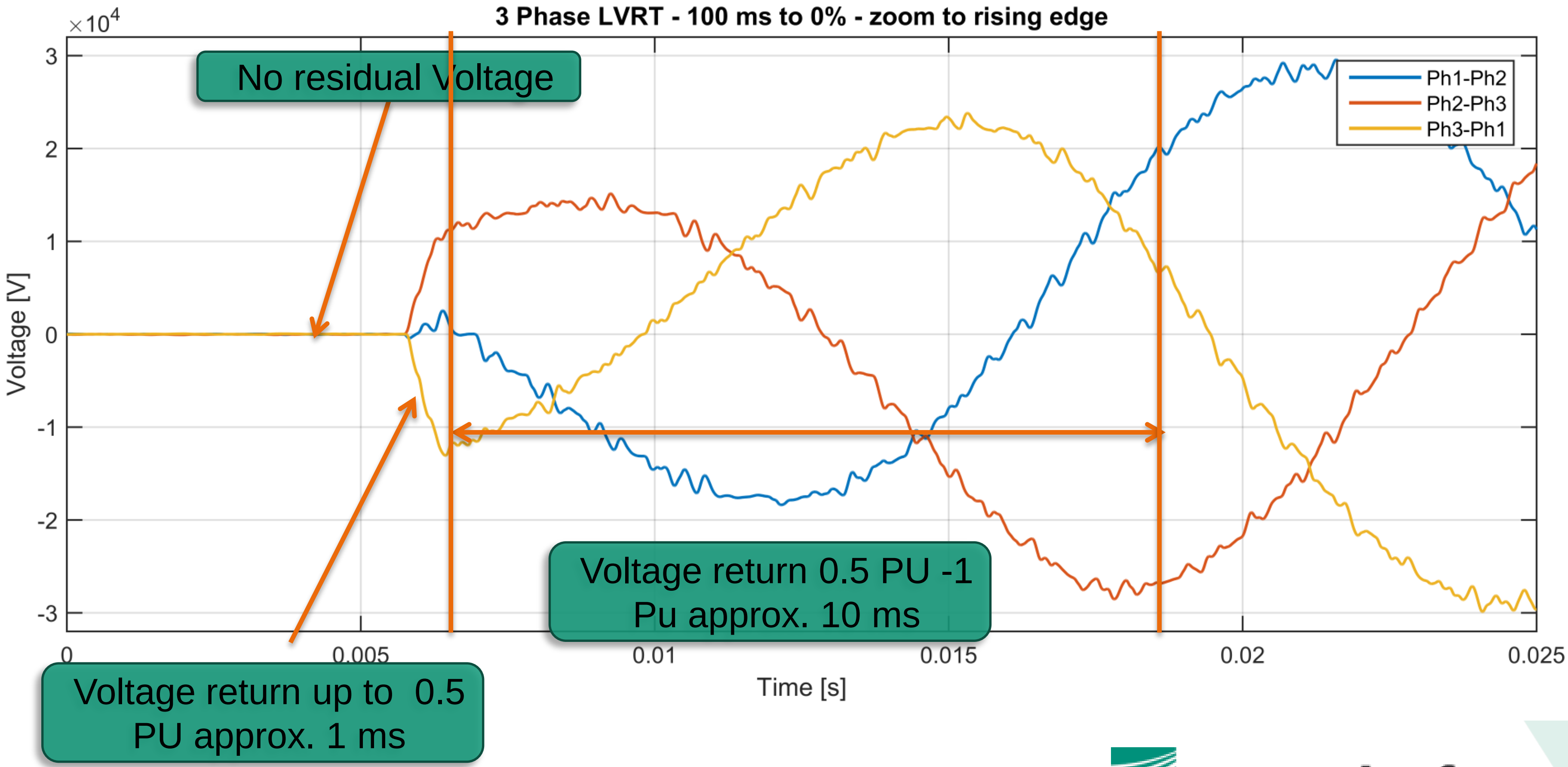
Detailed view on voltage return



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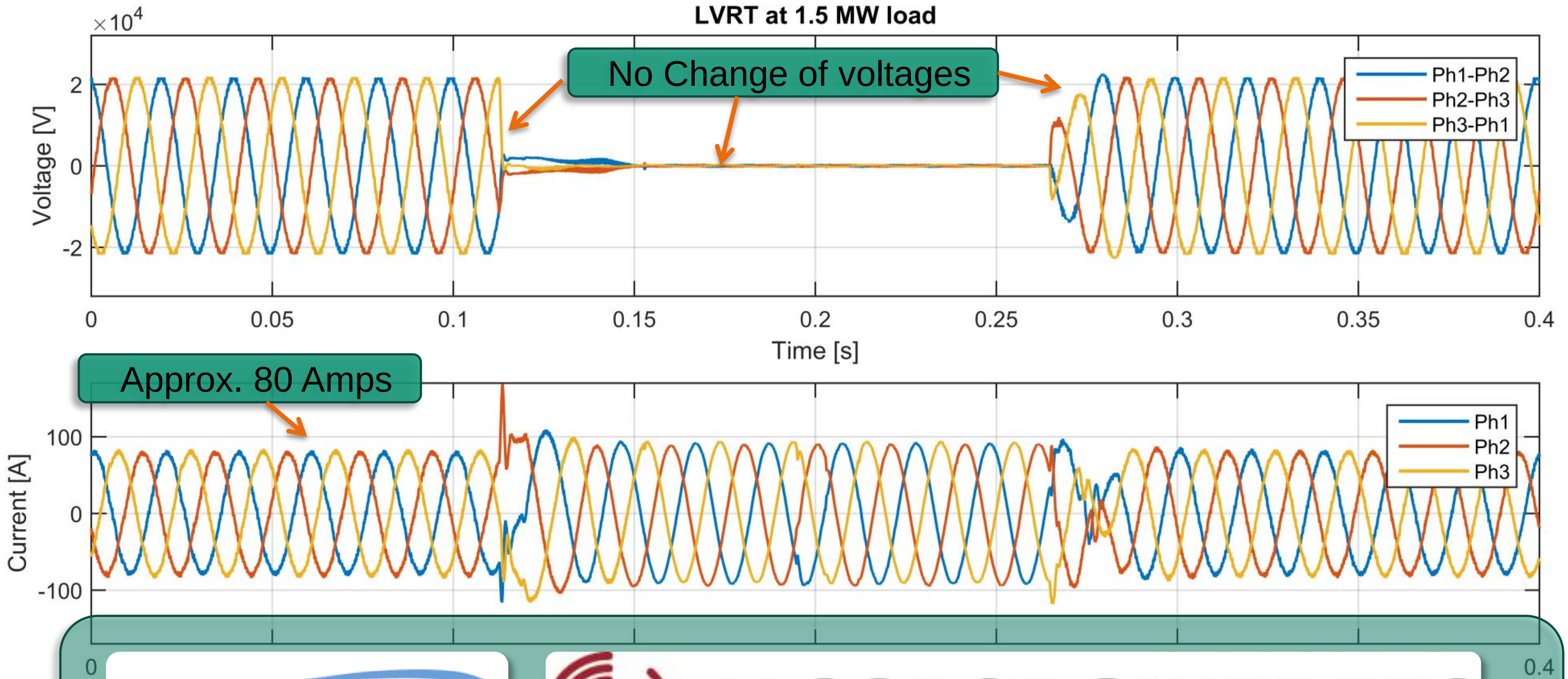
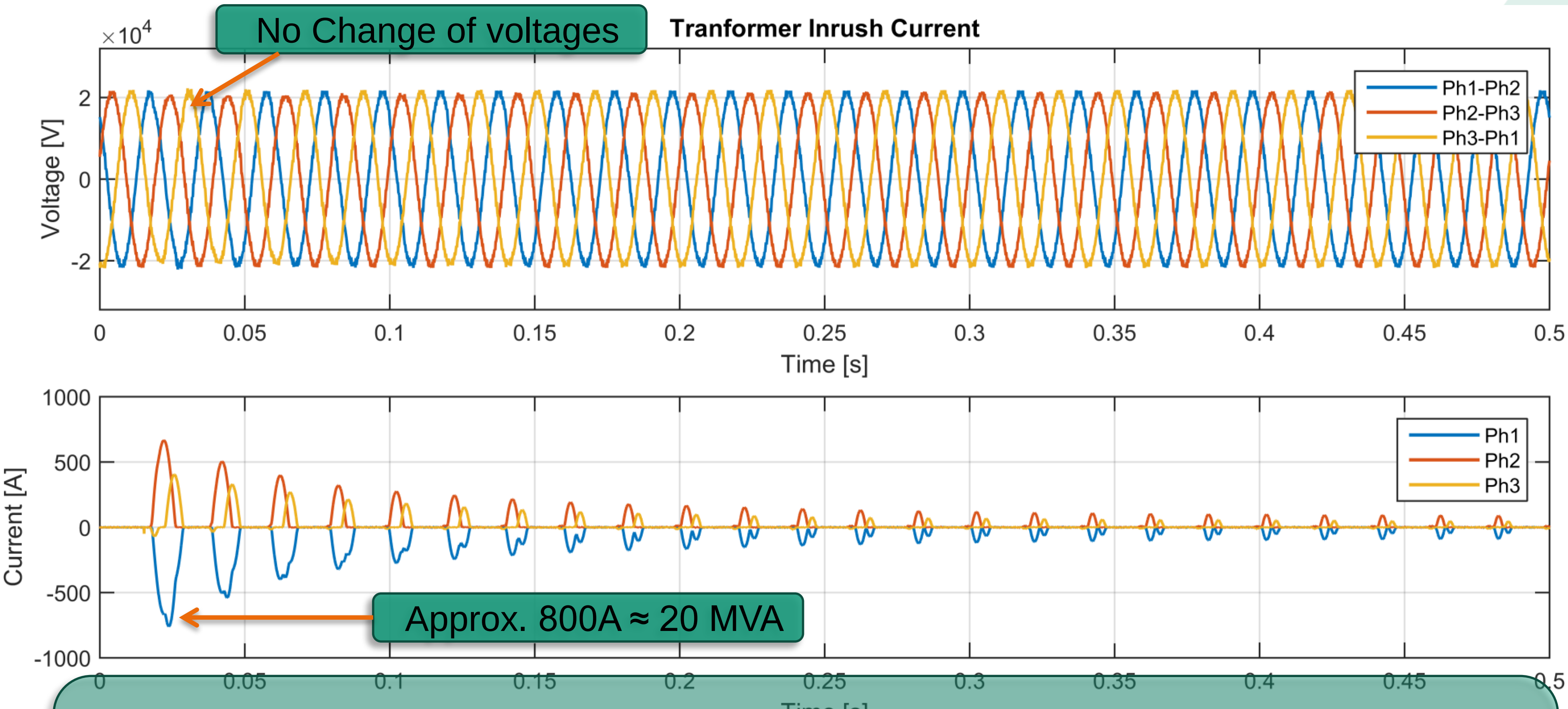
Electrical certification of JPT Wind turbine



Transformer – Inrush Current



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Summary Gridsimulator

- 3 different tapping for adjustment of rated Voltages 10/20/36 kV
- 3 complete independent controllable phases
- Controllable amplitude
- LVRT Capability to 0V
- HVRT Capability up to 130% with additional tapping
- Controllable grid impedance
- Controllable phase angle
- Frequency 45 … 65 Hz
- Injection of harmonics

Example of 36 kV Tapping

Description	36 kV	33 kV
Continuous Power	15 MVA	13,54 MVA
Short Term < 3s	30 MVA	27,09 MVA
Short Term < 150ms	43,09 MVA	39,50 MVA
Inverter Limit	44 MVA	40,33 MVA
Virtual Impedance	up to 300 MVA	up to 251,5 MVA
Voltage	0 … 130%	0 .. 142%
	0 … 46,8 kV	0 … 46,8 kV
Low THD, static Voltage	THD <2%	THD <2%
Medium THD, Dynamic Voltage	THD <5%	THD <5%

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Actual Projects and Outline

JACOBSPOWERTEC
VENPOWER-SYSTEM INSIDE

FINISHED

Adwen
AN AREVA GAMESA COMPANY

Test bench available
after 1. quarter 2017

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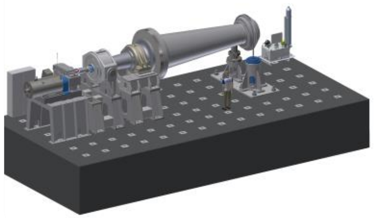
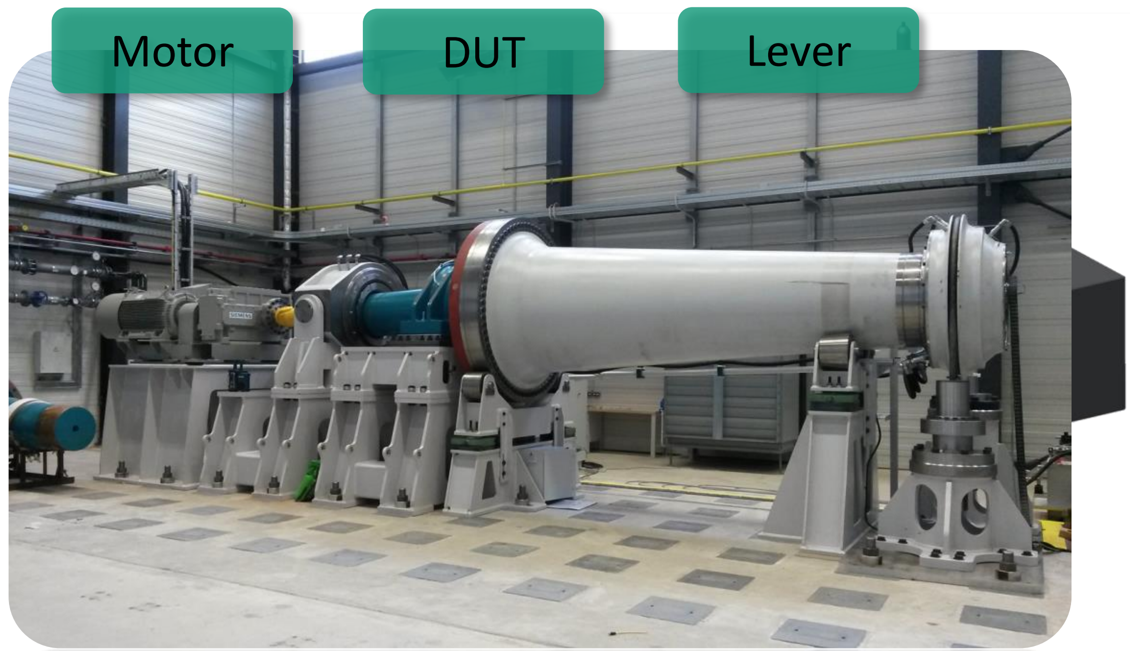



BeBen XXL – Main shaft testing



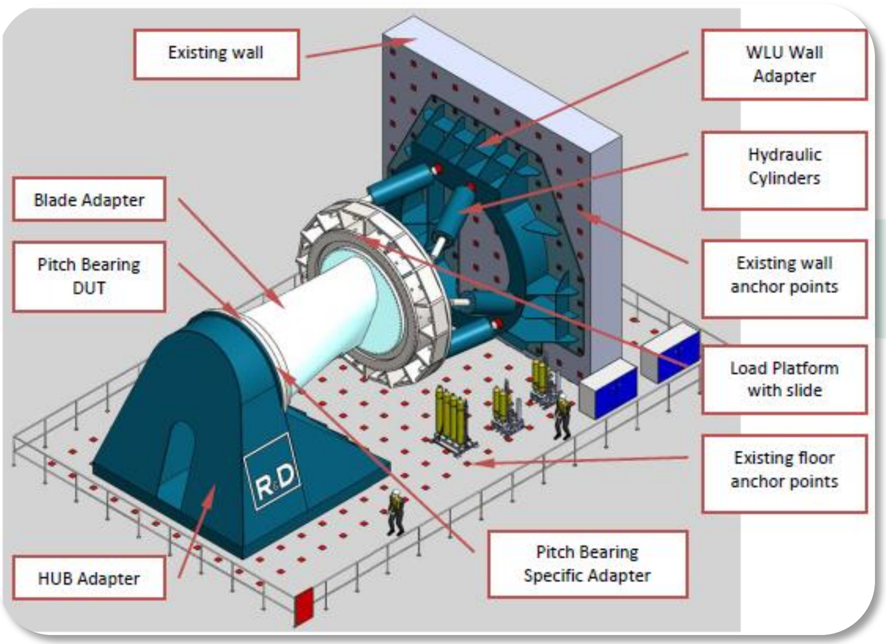
Key points

- Max bending moment 15 MNm
- 350 kW drive unit
- Modular adapter
- 7x15m clamping field

Possible tests

- Accelerated lifetime test
- Model validation
- Functional testing

Outline
HAPT (**H**ighly **Accelerated P**itch bearing **T**est)



Motivation

- Currently no method for pitch bearing lifetime prediction
- Current test rigs exclude interaction with hub and blade Current test rigs exclude interaction with hub and blade

Goal

- Development of suitable test rig and test method

Capabilities

- Dynamic generation of bending moments, axial and radial forces
- Emulation of blade and hub stiffness
- Continuous pitching under load possible
- Pitch bearing diameter of 4 – 4,5 m (~ 10 MW turbine)
- Turbine service life in 6 month test time

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THANK YOU FOR YOUR ATTENTION

Video ?

Any questions?

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